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TITLE: Indirect calibration of polymer characterization systems

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PARENT-CASE:

This application claims priority under 35 U.S.C. Sec. 119(e) to U.S. Provisional Application Ser. No. 60/080,652, filed Apr. 3, 1998 by Safir et al., which is hereby incorporated by reference for all purposes. This application is related to the following U.S. patent application filed on the date even herewith, each of which is hereby incorporated by reference for all purposes: U.S. Ser. No. 09/285,393, entitled "Automated Sampling Methods for Rapid Characterization of Polymers", filed Apr. 2, 1999 by Petro et. al. entitled "High-Temperature Characterization of Plymers", filed Apr. 2, 1999 by Petro et al. U.S. Ser. No. 09/285,335, entitled "Flow-Injection Analysis and Variable-Flow Light Scattering Apparatus and Methods for Characterizing Plymers", filed Apr. 2, 1999 by Nielsen et al. now U.S. Pat. No. 6,175,409 issued on Jan. 16, 2001 and U.S. Ser. No. 09/285,363 entitled "Rapid Characterization of Plymers", filed Apr. 2, 1999 by Safir et al.

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Brief Summary Text - BSTX:

Liquid chromatography is well known in the art for characterizing a polymer sample. Liquid chromatographic techniques employ separation of one or more components of a polymer sample from other components thereof by flow through a chromatographic column, followed by detection of the separated components with a flow-through detector. Approaches for liquid chromatography can vary, however, with respect to the basis of separation and with respect to the basis of detection. Gel permeation chromatography (GPC), a well-known form of size exclusion chromatography (SEC), is a frequently-employed chromatographic technique for polymer size determination. In GPC, the polymer sample is separated into components according to the hydrodynamic volume occupied by each component in solution. More specifically, a polymer sample is injected into a mobile phase of a liquid chromatography system and is passed through one or more chromatographic columns packed with porous beads. Molecules with relatively small hydrodynamic volumes diffuse into the pores of the beads and remain therein for longer periods, and therefore exit the column after molecules with relatively larger hydrodynamic volume. Hence, GPC can characterize one or more separated components of the polymer sample with respect to its effective hydrodynamic radius ($R_{sub.h}$). Another chromatographic separation approach is illustrated by U.S. Pat. No. 5,334,310 to Frechet et al. and involves the use of a porous monolithic stationary-phase as a separation medium within the chromatographic column, combined with a mobile-phase composition gradient. (See also, Petro et al,

Molded Monolithic

Rod of Macroporous Poly(styrene-co-divinylbenzene) as a Separation Medium for

HPLC Synthetic Polymers: "On-Column"

Precipitation-Redissolution Chromatography

as an Alternative to Size Exclusion Chromatography of Styrene Oligomers and

Polymers, Anal. Chem., 68, 315-321 (1996); and Petro et al, Immobilization of

Trypsin onto "Molded" Macroporous Poly (Glycidyl

Methacrylate-co-Ethylene

Dimethacrylate) Rods and Use of the Conjugates as

Bioreactors and for Affinity

Chromatography, Biotechnology and Bioengineering, Vol. 49, pp. 355-363

(1996)). Chromatography involving the porous monolith is reportedly based on a

precipitation/redissolution phenomenon that separates the polymer according to

size--with the precipitated polymer molecules selectively redissolving as the

solvent composition is varied. The monolith provides the surface area and

permeation properties needed for proper separation. Other separation

approaches are also known in the art, including for example, normal-phase

adsorption chromatography (with separation of polymer components being based on

preferential adsorption between interactive functionalities of repeating units

and an adsorbing stationary-phase) and reverse-phase chromatography (with

separation of polymer components being based on hydrophobic interactions

between a polymer and a non-polar stationary-phase). After separation, a

detector can measure a property of the polymer or of a polymer component--from

which one or more characterizing properties, such as molecular weight can be

determined as a function of time. Specifically, a number of molecular-weight

related parameters can be determined, including for example: the weight-average

molecular weight ($M_{sub.w}$), the number-average molecular weight ($M_{sub.n}$), the

molecular-weight distribution shape, and an index of the

breadth of the molecular-weight distribution ($M_{sub.w} / M_{sub.n}$), known as the polydispersity index (PDI). Other characterizing properties, such as mass, particle size, composition or conversion can likewise be determined.

Detailed Description Text - DETX:

The chromatographic column 102 further comprises a separation medium having a stationary-phase within the separation cavity. The separation medium can consist essentially of a stationary-phase or can also include, in addition thereto, an inert support for the stationary phase. The column 102 can also comprise one or more fillers, frits (for separation medium retention and/or for filtering), and various fittings and features appropriate for preparing and/or maintaining the column for its intended application. The particular separation medium to be employed as the stationary-phase is not critical, and will typically depend on the separation strategy for the particular chemistry of the polymer samples of interest, as well as on the desired detection, sample-throughput and/or information quality. Typical stationary-phase media can be a bed of packed beads, rods or other shaped-particles, or a monolithic medium (typically greater than about 5 mm in thickness), each of which can be characterized and optimized for a particular separation strategy with respect to the material, size, shape, pore size, pore size distribution, surface area, solvent regain, bed homogeneity (for packed shaped-particles), inertness, polarity, hydrophobicity, chemical stability, mechanical stability and solvent permeability, among other factors. Generally preferred stationary-phase include porous media (e.g., porous beads, porous monoliths), such as are

suitable for gel permeation chromatography (GPC), and media suitable for precipitation-redissolution chromatography, adsorption chromatography, and/or reverse-phase chromatography. Non-porous particles or empty columns and/or capillaries with adsorptive walls can be used as well. If beads are employed, spherical beads are preferred over other shapes. Particularly preferred stationary-phase media for polymer characterization applications are disclosed in greater detail below, but can generally include silica, cross-linked resins, hydroxylated polyglycidyl methacrylates, (e.g., poly(2-3-dihydroxypropylmethacrylate)), poly(hydroxyethyl methacrylate), and polystyrenic polymers such as poly(styrene-divinylbenzene).